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(12) # EUROPEAN PATENT APPLICATION

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(54) **System for generating a texture mapped perspective view.**

(57) A method and apparatus for providing a texture mapped perspective view for digital map systems. The system includes apparatus for storing elevation data (10), apparatus for storing texture data (24), apparatus for scanning a projected view volume (12) from the elevation data storing apparatus, apparatus for processing (14), apparatus for generating a plurality of planar polygons (16) and apparatus for rendering images. The processing apparatus further includes apparatus for receiving the scanned projected view volume from the scanning apparatus, transforming the scanned projected view volume from object space to screen space, and computing surface normals at each vertex of each polygon so as to modulate texture space pixel intensity. The generating apparatus generates the plurality of planar polygons from the transformed vertices and supplies them to the rendering apparatus which then shades each of the planar polygons. In one alternate embodiment of the invention, the polygons are shaded by apparatus of the rendering apparatus assigning one color across the surface of each polygon. In yet another alternate embodiment of the invention, the rendering apparatus interpolates the intensities between the vertices of each polygon in a linear fashion as in Gouraud shading.

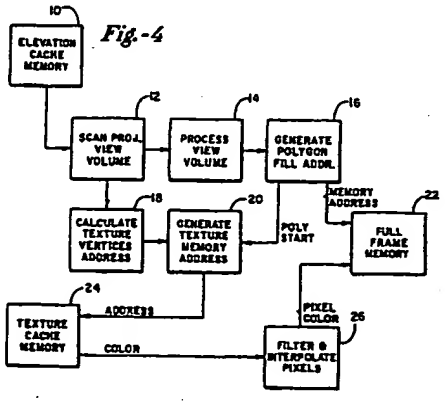

Fig.-4

EP 0 454 129 A2

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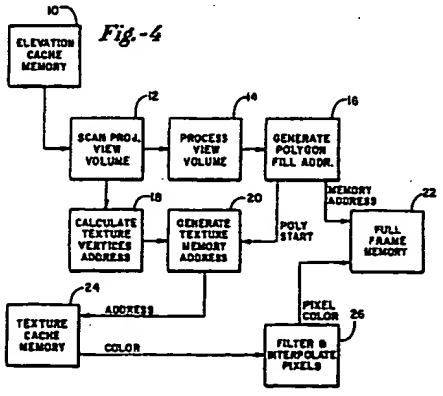


Fig.-4

EP 0 454 129 A2

The present invention is directed to a system for generating texture mapped perspective views for a digital map system according to the preamble of the independent claims.

BACKGROUND OF THE INVENTION

Texture mapping is a computer graphics technique which comprises a process of overlaying aerial reconnaissance photographs onto computer generated three dimensional terrain images. It enhances the visual reality of raster scan images substantially while incurring a relatively small increase in computational expense. A frequent criticism of known computer-generated synthesized imagery has been directed to the extreme smoothness of the image. Prior art methods of generating images provide no texture, bumps, outcroppings, or natural abnormalities in the display of digital terrain elevation data (DTED).

In general, texture mapping maps a multidimensional image to a multidimensional space. A texture may be thought of in the usual sense such as sandpaper, a plowed field, a roadbed, a lake, woodgrain and so forth or as the pattern of pixels (picture elements) on a sheet of paper or photographic film. The pixels may be arranged in a regular pattern such as a checkerboard or may exhibit high frequencies as in a detailed photograph of high resolution LandSat imagery. Texture may also be three dimensional in nature as in marble or woodgrain surfaces. For the purposes of the invention, texture mapping is defined to be the mapping of a texture onto a surface in three dimensional object space. As is illustrated schematically in Figure 1, a texture space object T is mapped to a display screen by means of a perspective transformation.

The implementation comprises two processes. The first process is geometric warping and the second process is filtering. Figure 2 illustrates graphically the geometric warping process for applying texture onto a surface. This process applies the texture onto an object to be mapped analogously to a rubber sheet being stretched over a surface. In a digital map system application, the texture typically comprises an aerial reconnaissance photograph and the object mapped is the surface of the digital terrain data base as shown in Figure 2. After the geometric warping has been completed, the second process of filtering is performed. In the second process, the image is resampled on the screen grid.

It is the object of the present invention to provide a texture mapped perspective view architecture which addresses the need for increased aircraft crew effectiveness, consequently reducing workload, in low altitude flight regimes characterized by the simultaneous requirement to avoid certain terrain and threats, thereby increasing crew situational awareness.This object is achieved by the characterizing features of the independent claims. Further advantageous embodiments of the inventive system may be taken from the sub-claims.

Crew situational awareness has been increased to some degree through the addition of a perspective view map display to a plan view capability which already exists in digital map systems. See, for example, EP-A2-0 341 645. The present invention improves the digital map system capability by providing a means for overlaying aerial reconnaissance photographs over the computer generated three dimensional terrain image resulting in a one-to-one correspondence from the digital map image to the real world. In this way the invention provides visually realistic cues which augment the informational display of such a computer generated terrain image. Using these cues an aircraft crew can rapidly make a correlation between the display and the real world.

The architectural challenge presented by texture mapping is that of distributing the processing load to achieve high data throughput using parallel pipelines and then recombining the parallel pixel flow into a single memory module known as a frame buffer. The resulting contention for access to the frame buffer reduces the effective throughput of the pipelines in addition to requiring increased hardware and board space to implement the additional pipelines. The system of the invention addresses this challenge by effectively combining the low contention attributes of a single high speed pipeline with the increased processing throughput of parallel pipelines.

SUMMARY OF THE INVENTION

A system for providing a texture mapped perspective view for digital map systems is provided. The invention comprises means for storing elevation data, means for storing texture data, means for scanning a projected view volume from the elevation data storing means, means for processing the projected view volume, means for generating a plurality of planar polygons and means for rendering images. The processing means further includes means for receiving the scanned projected view volume from the scanning means, transforming the scanned projected view volume from object space to screen space, and computing surface normals at each vertex of each polygon so as to modulate texture space pixel intensity. The generating means generates the plurality of planar polygons from the transformed vertices and supplies

engine draws these primitives and outputs pixels which are anti-aliased. The GAP transforms these polygons and passes them to the rendering engine. A complete 4x4 Euler transformation is performed. Typical macros include compass rose and range scale symbols. Given a macro command, the symbol generator produces the primitive graphics calls to the rendering engine. This mode operates in plan view only and implements two dimensional symbols. Those skilled in the art will appreciate that the invention is not limited to specific fonts. Three dimensional symbology presents the problem of clipping to the view volume. A gross clip is handled by the DSM in the cache memory at scan out time. The base of a threat dome, for example, may lie outside the orthographic projection of the view volume onto cache, yet a part of its dome may end up visible on the screen. The classical implementation performs the functions of tiling, transforming, clipping to the view volume (which generates new polygons), and then rendering. A gross clip boundary is implemented in cache around the view volume projection to guarantee inclusion of the entire symbol. The anomaly under animation to be avoided is that of having symbology sporadically appear and disappear in and out of the frame at the frame boundaries. A fine clip to the screen is performed downstream by the rendering engine. There is a 4K boundary around the screen which is rendered. Outside of this boundary, the symbol will not be rendered. This causes extra rendering which is clipped away.

Threat domes are represented graphically in one embodiment by an inverted conic volume. A threat/intelligence file contains the location and scaling factors for the generic model to be transformed to the specific threats. The tiling engine contains the connectivity information between the vertices and generates the planar polygons. The threat polygons are passed to the rendering engine with various viewing parameters such as mesh, opaque, dot, transparent, and so forth.

Graticles represent latitude and longitude lines, UTM klicks, and so forth which are warped onto the map in perspective. The symbol generator produces these lines.

Freeze frame is implemented in plan view only. The cursor is flown around the screen, and is generated by the symbol generator.

Programmable blink capability is accommodated in the invention. The DSM updates the overlay RAM toggle for display. The processor clock is used during variable frame update rate to control the blink rate.

A generic threat symbol is modeled and stored in the three dimensional symbol generation library. Parameters such as position, threat range, and angular threat view are passed to the symbol generator as a macro call (similar to a compass rose). The symbol generator creates a polygon list for each threat instance by using the parameters to modify the generic model and place it in the world coordinate system of the terrain data base. The polygons are transformed and rendered into screen space by the perspective view pipeline. These polygons form only the outside envelope of the threat cone.

Claims

1. System for providing a texture mapped perspective view of a plurality of polygons for a digital map system **characterized by**:
   (a) means for storing elevation data (10) for each polygon;
   (b) means for storing texture data (24) for each polygon;
   (c) means for scanning a projected view volume (12) coupled to the elevation data storing means;
   (d) means for processing (14) including means for receiving the scanned projected view volume from the scanning means, means for transforming the scanned projected view volume from object space to screen space (22) and means for computing surface normals at each vertex of each polygon so as to project elevation posts;
   (e) tiling engine means (40) coupled to the processing means for generating a plurality of planar polygons from the transformed vertices;
   (f) a texture engine means (30) for tagging the elevation posts with corresponding addresses in texture space; and
   (g) means (34) coupled to the tiling engine means (40) and texture engine means (30) for rendering images from the planar polygons by shading between the tagged vertices of each polygon.

2. A system for providing a texture mapped perspective view for a digital map system **characterized by**:
   (a) a cache memory (10) for storing terrain data;
   (b) a shape address generator (12) for scanning cache memory (10) and generating shapes for plan view, perspective view, intervisibility and radar simulation;
   (c) a geometry engine (36) coupled to the cache memory (10) for
      (i) transformation of terrain data from object space to screen space,
      (ii) generating three dimensional coordinates, and

Fig.-1

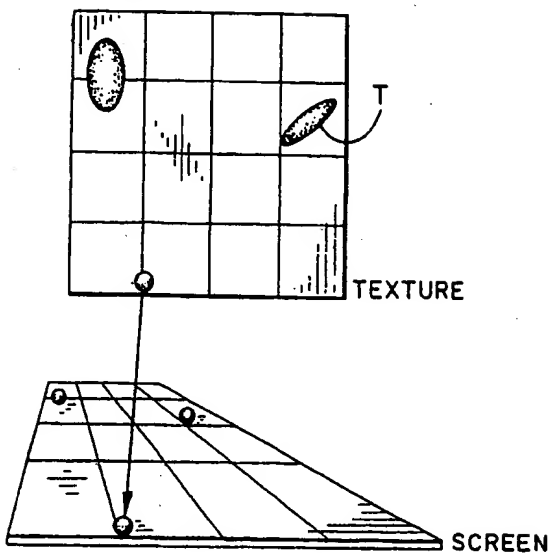
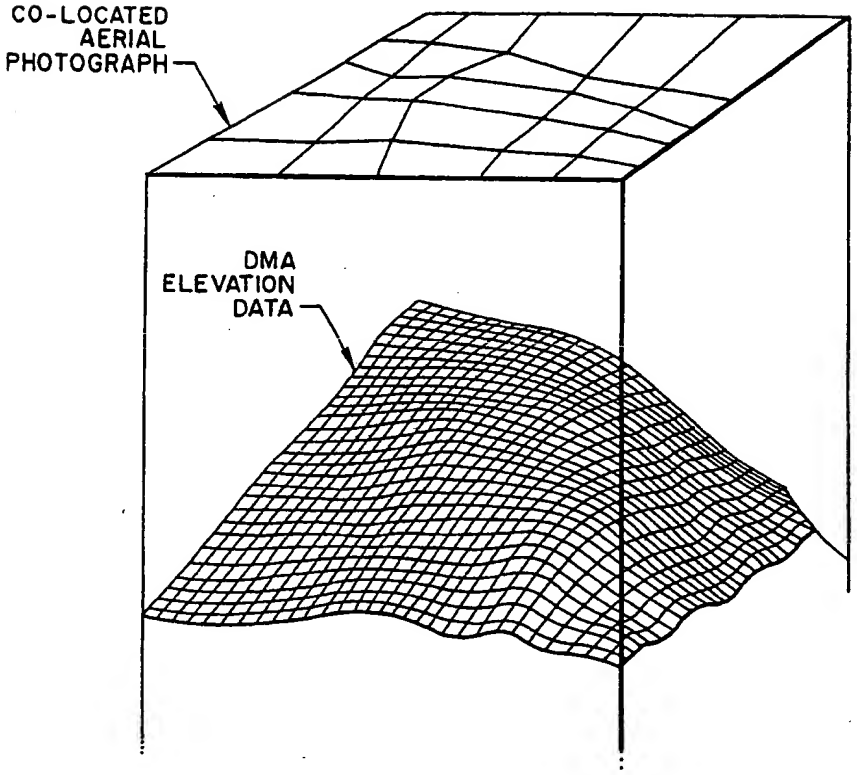

T
TEXTURE
SCREEN

Fig.-2


CO-LOCATED
AERIAL
PHOTOGRAPH
DMA
ELEVATION
DATA